Exploiting Metadata for Off-line Handwritten Documents: Modeling and Applications

Ph.D Candidacy: Jin Chen

Thesis Advisor: Daniel Lopresti

Computer Science & Engineering, Lehigh University, Bethlehem, PA, United States

Introduction

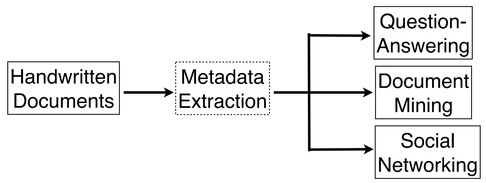
Document image analysis (DIA) is the subfield of digital image processing that aims at converting document images to a symbolic form for modification, storage, retrieval, reuse, and transmission [1]. However, more information is conveyed in addition to such a transcription, e.g., writer idiosyncrasies, data arrangement (tables, forms, etc.).

Metadata in Context [2]:

- *Descriptive Metadata:* describes a resource for discovery and identification, e.g., author, and writer idiosyncrasies.
- *Structural Metadata*: indicates how document components are organized, e.g., tables, pre-printed ruling lines, etc.

Thesis Hypothesis:

By exploiting various metadata in off-line handwritten documents, we are able to restore the original structure between documents, build new relationships from them, and facilitate problem solving in information retrieval tasks.



A high-level view of modules of document analysis system for various applications.

Table Detection in HW Documents

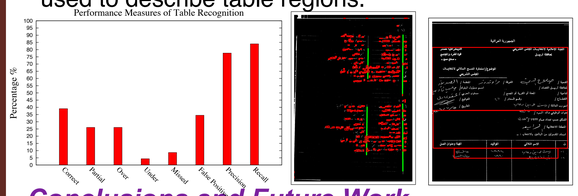
Table Detection via Dynamic Programming [3]

Each page is decomposed into:
1. one table
2. multiple tables

Row correlation is based on inside-space stream.

Table Detection Performance

- 62 Arabic handwritten documents are scanned at 600 dpi. The ground-truth for text regions (HW vs. MP) is available as bounding polygons.
- 20 pages for testing and the other 42 for training.
- Use area ratio-based measures proposed in Shafait and Smith [5], where bounding boxes are used to describe table regions.



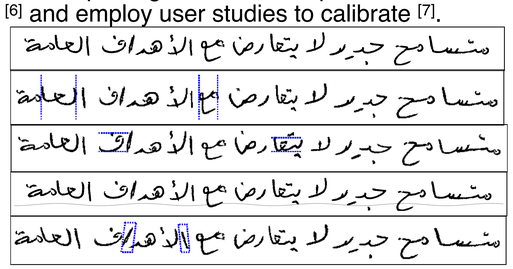
Conclusions and Future Work

- Existing methods in MP documents do not completely solve the problem in HW documents.
- Part of the errors are caused by complicated layouts, such as letter forms, signatures, etc.
- Future work includes detection methods requiring no row segmentation, and better layout analysis.

Writer ID w/ Severe Data Constraints

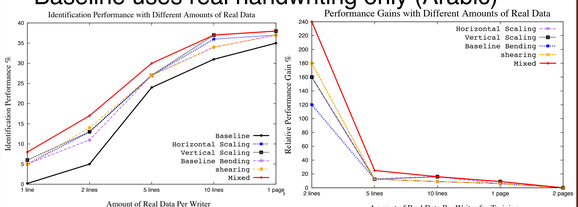
Scenarios and Methodologies

- Although usually assumed sufficient for research, data can become a problem for real-world writer ID, e.g., authors are unavailable, uncooperative.
- Model-Generated Handwriting and Model-Perturbed Handwriting can be used.
- We adopt Varga and Bunke's perturbation model [6] and employ user studies to calibrate [7].

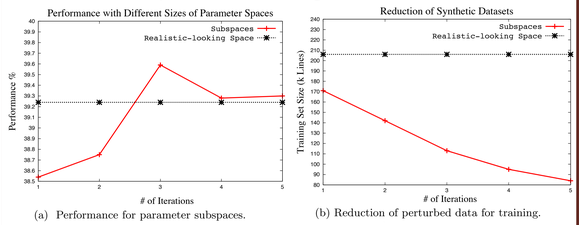


Writer Identification Performance

- Baseline uses real handwriting only (Arabic)



- Better Subspace Searching



(a) Performance for parameter subspaces. (b) Reduction of perturbed data for training.

Conclusions and Future Work

- MPH can be useful for writer ID, in addition to handwriting recognition.
- It is possible to find better subspace of parameters s.t. more gains are acquired.
- Future work includes simulation-based approach that requires no expensive classifier re-training.

Model-based Ruling Line Detection

Scenarios and Methodologies

- Pre-printed ruling lines are used to help people write neatly on paper. In document analysis, however, they create challenges for handwriting recognition and writer identification.
- Rewrite the *residual* function and solve it:

$$\begin{bmatrix} \Sigma 1 & \Sigma i & \Sigma x_{i,j} \\ \Sigma i & \Sigma i^2 & \Sigma i\ x_{i,j} \\ \Sigma x_{i,j} & \Sigma i\ x_{i,j} & \Sigma x_{i,j}^2 \end{bmatrix} \times \begin{bmatrix} \hat{\beta}_0 \\ \hat{\beta}_1 \\ \hat{\beta}_2 \end{bmatrix} = \begin{bmatrix} \Sigma y_{i,j} \\ \Sigma i\ y_{i,j} \\ \Sigma x_{i,j}\ y_{i,j} \end{bmatrix}$$

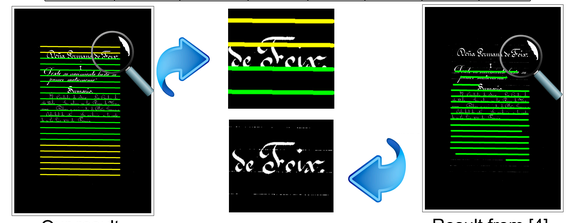
- Ground-truth on the page level and measure directly the detection errors as:

$$D[i] = M_{algorithm}[i] - M_{ground-truth}[i]$$

Ruling Line Detection Performance

Table 2. Performance comparison of our model-based ruling line detection and an existing algorithm [4].

Stats.	$\mathcal{P}.x$	$\mathcal{P}.y$	$\mathcal{L}$	$\mathcal{K}$	β_1	β_2	$\mathcal{H}$
Synthesis Dataset							
μ	-4.16	0.55	6.9	0	0	-0.01	0
σ	5.60	2.18	5.11	0	0.01	0.05	1.41
Germana Dataset							
μ	-12.30	3.80	12.85	0.25	-0.49	-0.09	0.25
σ	39.01	20.70	34.03	1.25	2.24	0.26	0.22
Germana Dataset (an existing method [4])							
μ	-49.40	57.60	70.40	-1.20	-2.40	0.02	0
σ	62.64	113.30	62.12	5.68	8.82	1.09	0



Conclusions and Future Work

- Propose an effective model-based ruling line detection algorithm.
- Scale-up experiments and the effects on applications such as writer ID are ongoing.

A Short Bio

Jin Chen has finished his fourth year at Lehigh University pursuing a Ph.D degree. He joined the Pattern Recognition Lab in Fall 2007 working with Professor Daniel Lopresti since then, on on-line/off-line handwriting related problems. He expects to graduate by May 2012.

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